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Published in:
SETAC Europe 21st Annual Meeting Abstract Book

Publication date:
2011

[Link back to DTU Orbit](#)

Citation (APA):
Lützhøft, H-C. H., Qualmann, S., Kusk, K. O., & Mikkelsen, P. S. (2011). Whole Effluent Assessment of urban discharges. In *SETAC Europe 21st Annual Meeting Abstract Book* SETAC Europe.

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Whole Effluent Assessment of urban discharges

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1. Introduction

The European Water Framework Directive [1] and the Environmental Quality Standards Directive [2] lay down a framework for maintaining or obtaining good ecological and chemical status of European surface and coastal water bodies by the year 2015. EQSs have been set for a range of priority substances (PSs) and have to be obeyed either by the use of emission reduction or end-of-pipe technology. The original list of PSs only regulates 33 substances, so even if the EQSs are met for a given water body, other substances may cause harmful effects. The EQSs are only valid for the receiving waters. In other words, the discharges are allowed to be diluted, which will take place in a so called mixing zone.

The aim of this work was through Whole Effluent Assessment (WEA) to identify problematic urban discharges, e.g. stormwater, municipal wastewater, combined sewer overflow (CSO), industrial wastewater. Samples from around Copenhagen were therefore tested in the Larval Development Ratio (LDR) test using the marine crustacean *Acartia tonsa*. By studying the morphological developments, especially the change from larvae to juvenile is easily detected, it is possible to investigate the effects of a stressor. This organism is highly ecologically relevant, as the receiving compartment for discharges from Copenhagen is the brackish Baltic Sea, which in the surrounding of Copenhagen has a salt content about 15 ‰.

2. Materials and methods

Tests were performed in glass beakers containing 80 mL each and added approximately 60 eggs. Due to dilution by addition of nutrients and salts stock solutions, WEA was performed on the samples mainly at concentrations of 72%, however, some samples were studied at concentrations down to 0.01%. *Rhodomonas salina* algal stock solution was added twice during the test as a food source. After about 5 days the control group (n=12) reaches a developmental stage where the number of copepodites equals the number of nauplii and the test is terminated. The number of non-hatched eggs, nauplii and copepodites was determined in controls as well as in samples (n=6) and the effect was calculated as the ratio between the number of copepodites and the sum of the numbers of nauplii and copepodites. Ratios below or above 1 significantly (t-test) differing from the control group are considered inhibited or stimulated, respectively, both indicating an effect of the stressor. pH and oxygen content were measured at the beginning and at the end of the test, and were generally 8 and 9 mg/L, respectively.

3. Results and discussion

Figure 1 shows the results from the first sampling campaign, where all samples were tested at a concentration of 72%. For the wastewater treatment plants (WWTPs) all samples showed a significant stimulating effect ($P < 0.0001$), except for the inlet sample to WWTP Lynetten. The reason for this stimulating effect could be a too high content of nutrients, trace metals or minerals or other growth or development promoters. The same goes for the sedimentation basin of the power plant (PP) ($P = 0.0147$). The treated stormwater from Ørestaden was the only sample showing no effects on the development, i.e. the nauplii developed similar to the control ($P = 0.2939$). The sample from the PP concentrate showed a slightly inhibiting effect on the nauplii development ($P = 0.0044$). The rest of the samples, i.e. a range of industrial waste water samples, the inlet sample to the WWTP Lynetten and the CSO from Belvedere all showed that no nauplii reached the developmental stage of copepodites. In fact it was only in the treated water from gas plant that some nauplii were formed. For the vast majority of these samples less than 50%, but in most cases no eggs, were hatching. The eggs were some times even dissolved during the test period.

Based on the results from the first sampling campaign the outlet from the WWTP Damhusåen (stimulation), the CSO from Belvedere (full dissolution of the eggs) and the concentrate from the PP (slight inhibition) were selected for further studies. Figure 2 shows the concentration dependent responses and it is generally seen,

that the samples need a substantial dilution in order not to show effects on the test organism. Compared with the control group, the CSO from Belvedere needs to be diluted between 1,000 ($P=0.001$) and 10,000 ($P=0.1736$) times, the concentrate from the PP needs to be diluted around 1,000 ($P=0.126$) times and the outlet from the WWTP Damhusåen needs to be diluted at least 200 ($P=0.001$) times before the development of the organisms are comparable with the control group.

For comparison the results from the first sampling campaign have been included in the graph. It is realised that slightly different results are obtained. However, a difference between the two sampling campaigns is expected, as the results represent two different discharges. Therefore exact similar results can not be expected.

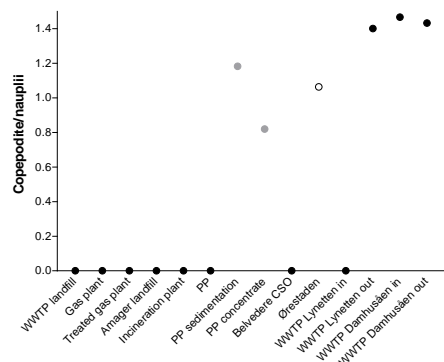


Figure 1 – Effects of WEA of the first sampling campaign. Samples were tested at a level of 72%. Circles indicate to what extent the development was affected – closed black circles indicate full inhibiting (<1) or stimulating (>1) statistical significant effects, closed grey circles indicate a slight effect and open circles indicate no effect compared with the control group, see text for details. For the samples showing full inhibiting effect all eggs were either dissolved or not hatching or when hatching no nauplii reached the copepodite stage. PP: Power plant.

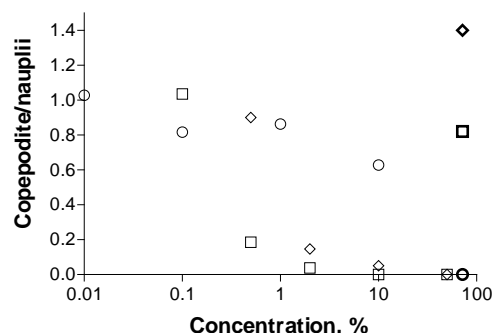


Figure 2 – Concentration dependent responses on selected samples from the second sampling campaign. The bold symbols \diamond (WWTP Damhusåen), \circ (Belvedere CSO) and \square (Power plant concentrate) represent the first measuring campaign (included for comparison), whereas the non-bold symbols \diamond , \circ and \square represent the second measuring campaign. Note the logarithmic x-axis.

4. Conclusions

Except for the stormwater from Ørestaden, which did not show any effects at a concentration of 72%, all samples need to be diluted to more than 72% - most of them need to be substantially more diluted as no organisms survived the test in a broad range of the samples. Especially three samples were studied in more detail resulting in at least a dilution of 200 times for the WWTP Damhusåen outlet. For the two other samples lowest observed effect concentration (LOEC) and no observed effect concentrations (NOECs) could be established. A LOEC of 0.5% and a NOEC of 0.1% was established for the water of the Power plant concentrate and a LOEC of 0.1% and a NOEC of 0.01% was established for the water sample of the Belvedere CSO.

5. References

- [1] EU (2000). The European Parliament and the Council of the European Union, Establishing a framework for Community action in the field of water policy. Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000.
- [2] EU (2008). The European Parliament and the Council of the European Union. Environmental quality standards in the field of water policy. Directive 2008/105/EC of the European Parliament and of the Council of 16 December 2008.

Acknowledgement – The presented results have been obtained within the framework of the project COHIBA (Control of Hazardous Substances in the Baltic Sea Region), a project coordinated by Finnish Environment Institute SYKE.